“THE EFFECT OF A COMBINED ELBOW & FOREARM POSITION ON GRIP STRENGTH IN ATHELETES”

A Dissertation Submitted

The Tamilnadu Dr.M.G.R.Medical University,

CHENNAI

In partial fulfilmentOf the requirements for the degree of

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“THE EFFECT OF A COMBINED ELBOW & FOREARM POSITION ON GRIP STRENGTH IN ATHELETES”

NANDHA COLLEGE OF PHYSIOTHERAPY

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The Dissertation Entitled

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Under the guidance of

Mr.T.LOGANATHAN,. M.P.T.(SPORTS),PGDHM,

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CHENNAI

Dissertation evaluated on**.....**

Internal Examiner External Examiner

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This is to certify that the dissertation entitled **"THE EFFECT OF A COMBINED ELBOW & FOREARM POSITION ON GRIP STRENGTH IN ATHELETES".** Is a bonafide complied work, carried out by **REG.NO: 271450081 . Nandha College of physiotherapy, Erode-638052**.in partial fulfilment for the award of degree in Master of Physiotherapy as per the doctrines of requirements for the degree of **THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY, Chennai-32.** This work was guided and supervised by Mr.T.LOGANATHAN,M.P.T.(SPORTS),PGDHM

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CERTIFICATE BY THE GUIDE

This is to certify the dissertation entitled **"THE EFFECT OF A COMBINED ELBOW & FOREARM POSITION ON GRIP STRENGTH IN ATHELETES"** is a bonafide complied work, carried out by **REGISTER NUMBER: 271450081** Nandha College of physiotherapy Erode-638052 in partial fulfilment for the award of degree in Master of Physiotherapy as per the doctrines of requirements for the degree of **THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY Chennai-32.** This work was done under my personal guidance.

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DECLARATION

I here, by declare and present my project work entitled **"THE EFFECT OF A COMBINED ELBOW & FOREARM POSITION ON GRIP STRENGTH IN ATHELETES"** is outcome of original research work was under taken and carried out by me under the guidance of **Mr.T.LOGANATHAN,M.P.T. (SPORTS),PGDHM**

To the best of my knowledge this dissertation has not been formed in any other basic for the award of any other degree, diploma, associateship, fellowship, previously form, any other medical university.

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On completing the project as I look back on the whole experience, from its very inception, I feel humbled. All along I was assumed of presence of **GOD** to who goes all the glory & honor for successful completion of this project.

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CONTENTS

INTRODUCTION

Hand is much more than a machine in the factory of human body. The hand is irreplaceable when it comes to performing any kind of movement be it gross or skilled. The prime function of hand is grip. Hand accounts for around 40% utility in the vocational rehabilitation. The importance of a normally functioning hand needs no emphasis in performing activities of daily living, whether in earning in living, practicing a hobby or allowing independence in daily activities. [1]

Hand and wrist are the most active and intricate parts of the upper extremity. Their mobility is enhanced by a wide range of movements at the shoulder and complementary movements at the elbow and forearm. The 28 bones, numerous articulation and 19 intrinsic and 20 extrinsic muscles of the wrist and hand provide tremendous variability of the movement. In addition to being an expressive organ of communication, the hand has a protective role and acts as both a motor and sensory organ, providing information such as temperature thickness texture, depth and shape as well as the motion of the object. [2]

Grip is an action or activity of the hand in moving, grasping or taking hold of an object between any two surfaces of the hand, the thumb may or may not be involved. Grip can be categorized as either power grip or precision handling. Each of these two categories has subgroups that further define the grip.[3]

Power grip is a forceful act resulting in flexion of all finger joints. When thumb is used, it acts as a stabilizer to the object held between the fingers and the palm.

Precision handling in contrast is the skillful placement of an object between fingers or fingers and thumb.[3]

Grip can be differentiated on the basis of the dynamic and static phases involved.

Power grip is the result of a sequence –

1. Opening of the hand.
2. Positioning of fingers.
3. Approaching the fingers to the object.
4. Maintaining a static phase that actually constitutes the grip.

In contrast precision handling shares the first 3 steps of the sequence but does not contain a static phase at all. In all precision handling the fingers and the thumb grasp the object with intention of manipulating it within the hand. In the power grip the object is

grasped so that the more proximal joints can move the object through space.[3]

Various types of power grip are cylindrical grip, spherical grip and hookgrip.

Various types of precision handling are tip-to-tip prehension, pad-to-pad prehension, pad to side prehension and lateral prehension

All articulations and musculature around wrist play their own role in all the types of the grip.

FDP performs the dynamic closing action, FDS assists when intensity of grip requires greater force

MCP flexors, abductors and adductors i.e. interossei helps in strong grip as same as extrinsic flexors. ED increases the joint compression and enhances the joint stability. Muscles of the hypothenar eminence (ADM, ODM, FDM) are active in cylindrical grip. FCU helps, as there is ulnar deviation during cylindrical grip.

The extrinsic finger and thumb flexors and the thenar muscles follow the pattern of activity and variability in the spherical grip. Hook grip never includes the thumb. The major activity is done by the FDS & FDP.

In lateral prehension extensor musculature plays part in the maintenance of the posture ED and lumbicrals are active to extend the phalanges. It is generally typified by the holding of a cigarette.

In precision handling all the smaller articulations come into play. During pad to pad prehension MCP and PIP joints are partially flexed, DIP may be extended or in slight flexion. FDS & FDP are the muscles involved in this grip.

Tip-to-tip prehension has same muscular activity as in pad-to-pad prehension. In this grip IP joint and thumb must have the range and available force to create nearly full joint flexion.

Pad-to-side prehension differs from the other forms of precision handling only in that the thumb is more adducted and less rotated. The activity level of the

FPB increases and that of the OP decreases. Activity of the adductor pollicis also increases; slight flexion of the distal phalanx of thumb is required.[3]

It is widely accepted that grip strength provides an objective index of the functional integrity of the upper extremity.[4] Grip strength is correlated with the upper extremity function[5], overall strength[6], biological growth and the amount of protein reserves in the body.[7] Because of this correlation, grip strength has been measured as an objective clinical measure in a variety of situations.

Grip strength has been used to assess general strength in order to determine work

capacity[8], to determine the extent of injury and disease process and the potential for the progress in rehabilitation.[9]

Grip strength is one of the many components to be considered in the examination of hand function. Grip strength is commonly used to evaluate the integrated performances of muscles by determining maximal grip force that can be produced in one muscular contraction.[10]

Measurement of grip strength is an important component of hand rehabilitation as it helps establish a baseline for treatment and it is a measure of effectiveness of therapy.[11] Testing grip strength is popular assessment used by
physical therapist and occupational therapist in range of clinical setting.[12] It is easy to perform, reliable and produces a result, which is simple.

Wide range of instruments is available to measure both dynamic and static grip strength. Grip strength measurement devices falls into four basic categories: hydraulic, pneumatic, mechanical and strain gauges.[13]

It is generally agreed that a standardized testing protocol and position is important for reliability and to compare results with normative data. Variations of the testing position when using the same instrument can significantly influence the results obtained. Variations from testing position have been observed to affect the grip strength in number of ways. Following are some studies –

Standing has been found to result in higher grip strength than when sitting.[14]

Shoulder flexion at 180° has found to result in greater grip strength.[15]

Greatest grip strength in full extension of elbow.[14] Also in 90° of elbow flexion.[16]

Forearm in supination produces greatest grip strength than forearm in midprone.

Wrist position also affects grip strength.[18]

Most of the studies done were concentrated on position of a single upper limb joint having an effect on grip strength. Our study is concerned with how variation in elbow joint and forearm position affects the grip strength. This will have some bearing in situation like immobilization of forearm and elbow in their musculoskeletal conditions like supracondylar fracture of humerus

OBJECTIVES

- To determine the grip strength in the different combinations of elbow joint and forearm positions.

- To compare the grip strength in the different combinations of elbow joint and forearm positions.

HYPOTHESIS

NULL HYPOTHESIS:

There is no significant difference between grip strength in various combinations of elbow joint and forearm position.

ALTERNATE HYPOTHESIS:

There is significant difference between grip strength in various combinations of elbow joint and forearm position.

1. **Agnew PJ, Maas F(1982):**The sex factor showed males to be significantly better "grip strength," in "moving large heavy objects," and "large light objects," except in the 66-99 age interval where females were significantly better on teh last 2 variables. Females performed better on "writing" and were generally better in "manipulating small objects.

2. **Carole Fraser, Jane Benten (1983):**It was concluded that patients' occupations must be considered when determining whether they have achieved full recovery of power grip following injury.

3. **Ferraz MB[1], Ciconelli RM, Araujo PM, Oliveira LM, Atra E (1992).**There was a statistically significant correlation between grip strength and morning stiffness, grip strength and hand function, and grip strength and number of active joints. In rheumatoid arthritis trials, grip strength should be assessed at the same time of the day. Elbow flexion does not play a role in grip strength measurement.

4. **Gilbert JC, Knowlton RG (1983):**Based upon a discriminant analysis performed by gender, DEV was found to be the only significant predictor for females with DEV, SLP and WTRATIO being significant predictors for the males. It was concluded that S and F subjects can be determined from the results of a maximal isometric grip strength test based upon a simple configuration analysis of an isometric force curve.

5. **Hazelton FT, Smidt GL, Flatt AE, Stephens RI (1975):**The percentage distribution of the total force produced by the finger flexors to each individual finger bear a constant relationship regardless of wrist position. The magnitude of the total force produced does vary with wrist position.

6. **Janda DH, Geiringer SR, Hankin FM, Barry DT.(1987):**Healthy volunteers were evaluated with standard grip strength measurement and electromyographic recordings in order to characterize normal patterns. These recordings were found to be relatively uniform and reproducible.

7. **Mathiowetz V, Rennells C, Donahoe L (1985).**A significantly stronger grip strength measurement in the 90 degree elbow flexed position than in the fully extended position. For evaluation of key pinch strength, both hands were stronger in the elbow flexed position, but only the right hand was significantly stronger. This study supports the use of the elbow flexed position in standardized grip and key pinch evaluations.

8. **McGarvey SR, Morrey BF, Askew LJ, An KN (1984):**Isometric strength measurements of grip, pronation, supination, and elbow extension and flexion on dominant and nondominant sides were made on 40 normal subjects (age range, 40-70 years) to investigate the variability of isometric strength at different times of the day. Statistically significant differences were found in certain pronation, supination, and grip comparisons. No statistically significant difference was found in extension and flexion. Although significant, the absolute change in strength at different times of the day was small and showed no consistent trend.

9. **Nwuga VC(1975):**The results showed that there was no apparent correlation between maximal grip strength and endurance index in the male subjects, but there was a tendency for endurance index to decrease as maximal grip strength increases in the female subjects. Maximal grip strength and body weight were positively correlated in both the males and the females. There was no significant difference in endurance index between the males and the females.
10. **Patricia B. Trossman,Karen Butler ,SuleskiPing-Wu Li (1990):**It is recommended that the mean of three trials should be used to determine the criterion score when evaluating isometric grip strength with the work simulator.
11. **Petersen P[1], Petrick M, Connor H, Conklin D(1989):**In conclusion, this study showed that the 10% rule is valid for right-handed persons only; for left-handed persons, grip strength should be considered equivalent in both hands.

12. **Stephens JL[1], Pratt N, Michlovitz S (1996):** The Tekdyne intersession reliability of the non-surgical group was high (ICC = 0.971, SEM = 0.22 psi). There was no statistically significant difference between the ratios of the non-operated grip strengths across the three measurement devices, suggesting that the softer device did not promote greater force production by the operated hand.

13. **Smith RO, Benge MW (1985):** The results confirm that the standardization of grasp and pinch terminology and protocols for testing are vitally needed. Specific recommendations to continue this standardization process are recommended.

14. **Su CY[1], Lin JH, Chien TH, Cheng KF, Sung YT (1994).** The grip values of the standardized 90 degrees elbow flexed position were further analyzed to determine the average performances in the study population. For men, grip strength peaked within the 20 to 39 years age group and gradually declined thereafter. For women, the highest mean grip strength measurement was recorded in the 40- to 49-year-old age group and then deteriorated with age.

Purpose of grip strength testing

Grip strength testing has been used in variety of clinical areas and for multiple purposes such as

1. The assessment of upper limb impairment.[19]
2. In evaluating work capacity for those with hand injuries. [20]
3. In evaluating work related injuries.[21]
4. The evaluation of people with other impairment and disabilities such as RA[22]
5. Chronic fatigue syndrome. [23]
6. Developmental disabilities. [24]
7. Determining the efficacy of different treatment for people with range of disabilities.[25]
8. As part of an overall fitness.[26]

Instruments

Wide ranges of instrument are used in testing static and dynamic grip strength.
A survey in the USA found that almost 80% used the hydraulic dynamometer called Jamar dynamometer while determining grip strength.[27]

Pneumatic instrument use the compression of an air filled bulb or bag to determine grip pressure. Pneumatic instrument include the modified sphygmomanometer. [28]
Martin vigorimeter with 3-bulb size is another pneumatic instrument.[29]Tekdyne dynamometer is also pneumatic instrument.[30]

Mechanical instruments record grip strength based on the amount of tension produced in a steel spring. Collins dynamometer is kind mechanical instruments.[31] Strain gauges are also used in measuring grip strength.[32]

Testing positions.

Forearm position in supination produces greatest grip strength followed by the forearm in neutral position with pronation producing the lowest strength. [17]

A testing posture and elbow position has effect on grip strength which found that there was significant difference between grip strength measured in subjects sitting with elbow in 90°flexion and standing with elbow in full extension. [14]

According to a study on effect of elbow position on grip strength, the results indicated significantly strong grip strength measurement in flexed position when compared with measurement in fully extended position of elbow. [16]

Position of upper extremity might influence grip measurement and called it standardized arm position which is subjects seated with shoulder adducted & neutrally rotated. The effect of wrist position on grip strength, found no significant difference between any combination of 0°& 15° of wrist extension or ulnar deviation. [34]

It was found that a body position affects the grip strength. Grip strength measured while subjects were standing was stronger than those measured when subjects were either sitting or supine. [35]

A study on effect of wrist position on grip strength concluded that no difference in grip strength for wrist positioned in neutral, 15°& 30° of extension and significantly lower strength scores with the wrist joint positioned in 15 °of flexion. [36]

A study on effect of elbow position on grip strength showed no relationship between elbow position and grip strength.[37]

A study on effect of grip strength in different positions of elbow and shoulder indicated in greater grip strength on the same instrument than in the standard 0º position.[15]

When subjects were able to self select their wrist position during testing, the optimum position was found to be 35°wrist extension and 7°ulnar deviation and any deviation from this position resulted in reduced grip strength. Also it was noted that wrist extension was inversely related to the size of the object grasped. [38]

Testing position is described as sitting in a straight backed with the feet flat on the floor.[13]

The shoulder adducted and neutrally rotated, elbow flexed at 90° degrees, forearm in a neutral position and the wrist between 0° and 30° degrees extension and between 0° and 15°of ulnar deviation. In all cases the arm should not be supported by the examiner or by an armrest. For the grip strength, the dynamometer is presented vertically and in line with the forearm to maintain the standard forearm and the wrist position.[39]

Number of trails

The preferred method used when obtaining grip strength is to use the mean of 3 trails.[40] Variations to this method have been investigated like one trial[41], best of two or three trails[42], no significant difference was found in all the studies.

Rest periods

The effect of rest period between 5 trails was done and found no significant difference between intertrail rest of 60s 30s & 15s although there was a pattern of decline grip strength across 5 trails.[43]

Instructions

A study found a significant difference between the volume of verbal command and isometric strength contractions where increase volume resulted in the increased strength. It is important therefore to use the same tone and volume of instruction each timeatestisconducted.[44]

Length of contractions

Isometric muscle contraction as required in many grip strength tests can cause potentially dangerous increase in blood pressure and pulse rate. The length of time maximal contraction was sustained has found to influence heart; systolic and diastolic blood pressure in healthy subjects. It is recommended that a 3s or less pinch or grip is usually sufficient to register a maximum reading.[45]

Warm up prior to testing

Activity specific warm ups in the form of submaximal grips have found to result in increased grip strength.[46]

Time of testing

Grip strength was found to be significantly stronger around midday than in early morning.[47]

Accuracy and reliability

Measurement issues related to the accuracy of the instrumentation used as well as reliability of the tests conducted are considered to be of great importance in the area of grip strength measurement.[48]

The accuracy of an instrument is related to instrument precision and calibration and is considered a form of criterion validity. The accuracy or precision of an instrument is determined by comparing results with known and accepted standard.[49]

Factors influencing grip strength.

Males have greater grip strength than females regardless of the testing instrument used.[50]

Grip strength has a curvilinear relationship to age which results in an increase in grip strength with increasing age to reach the peak at 30-45 years.[51]

A study to find relationship between body weight and height on grip strength showed positive co relationship. The positive association continues up to 98 kg in weight and 190 cm in height.[52]

Dominance

Study on effect of grip strength in dominant and non-dominant hand showed that the grip strength of the dominant hand is approximately 10% greater than the non-dominant hand.[9]

Influence of work

The Type of work and leisure purists undertaken has found to influence grip strength.[11]

A study has found no difference in grip strength between employees from different occupational groups like clerical technical manual.[53]

A study found that heavy manual workers have the greatest grip strength followed by the light manual workers.[54]

Another study suggested that there is a greater influence from hobby purists and leisure interests than from work demands.[55]

Level of subject effort.

Producing a submaximal effort during strength testing has been associated with the terms such as symptom magnification; functional overlay abnormal illness behavior and faking.[56]

In maximal effort it is expected that the grip strength variation should be less than 20% and usually less than 10% and it is indicated that the variation in force in readings should not be greater than 10% when full volitional effort id applied.[57]

One study found that there was no statistical difference in variability between subjects giving maximal and submaximal efforts.[58]

A study found that maximal grips are usually attained at the positions two or three of

the dynamometer.[59]

A typical curve shape produced usually a referred as to bell shaped.[60] The bell shaped curve holds true for those with or without hand injury.[61] One study found subjects do not have bell shaped curve.[62]

3.1 STUDY DESIGN:

The study design used for this research was randomized observational study.

3.2 SAMPLE SIZE:

The study a sample consists of 100 healthy trained subjects of both the sexes in age group of 18 to 25 years selected randomly.

3.3 SOURCE OF DATA:

All subjects were students in age group of 18 to 25 years selected from Nandha educational institute.

Ethical consent was taken from the institute and volunteers.

3.4 INCLUSION CRITERIA:

1. Trainedsubject.
2. Athletes.
3. Normal healthy subjects in age group 18-25 years.

3.5 EXCLUSION CRITERIA:

1. Untrained subjects.
2. Non athletes.
3. History of fracture&dislocationof shoulder, arm, elbow, forearm, wrist & hand.
4. Restriction of movements of upper limb joints.
5. Any history of inflammatory joint disease, neurological disorder or injury to upper extremity.
6. Tightness, deformity and contractures in upper extremity.

3.6 APPARATUS AND EQUIPMENTS:

1. Hand Dynamometer: Baseline hydraulic hand dynamometer made by 'Baseline evaluation instruments USA'. (Figure no 1)
2. Goniometer: universal goniometer made by omega.
3. Weighing scale: standard weighing scale.
4. Height measuring device: Standard measuring inch tape.
5. Stop watch.
6. Materials: data recording sheet, pencil, high sitting chair without armrest, consent form.

3.7 METHOD:

All the details were recorded like name, age occupation, dominance, height and weight. Medical history was asked for scrutinizing the subjects, which come under exclusion criteria.

Prior to commencement of the data collection subjects were asked to read and acknowledge the consent form. Subjects were told about hand dynamometer and its use. How to use the hand dynamometer was demonstrated and subjects were asked to perform one isometric contraction. Risk of fatigue experience was explained to the subjects.

After all briefing and recording the demographic profile, subjects were made to sit on high sitting chair with straight back with feet flat on the floor. Upper limb was in following position shoulder adducted and neutrally rotated.

Elbow and forearm position as per the study requirement for measuring grip strength, which is mentioned below, wrist between 0° to 30° of extension and between 0° to 15° of ulnar deviation. For grip strength measurement, the dynamometer presented vertically in case of mid prone position of forearm and horizontally in case of supination and pronation and in line with forearm to maintain the forearm and wrist position.

Grip strength of the subject was recorded in the following position of elbow joint and forearm.

1. Elbow in 0° Extension.
    a) Fore arm in supination. (Figure no 2)
    b) Fore arm in mid prone. (Figure no 3)
    c) Forearm in pronation. (Figure no 4)
2. Elbow in 45° Flexion.
    a) Fore arm in supination. (Figure no 5)
    b) Fore arm in mid prone. (Figure no 6)
    c) Forearm in pronation. (Figure no 7)
3. Elbow in 90° Flexion.
    a) Fore arm in supination. (Figure no 8)
    b) Fore arm in mid prone. (Figure no 9)
    c) Forearm in pronation. (Figure no 10)

Subjects were asked to perform the task in each position for 3 times andbest attempt was taken as final reading

One-minute rest was given between each attempt to minimize the effect of fatigue.

No verbal encouragement or any kind of feedback was given. No external support or armrest was provided to the subjects.

3.8 VARIABLES

- **Independent variable:**
  - ✓ Shoulder position.
- **Dependent variable:**
  - ✓ Grip strength.

3.9PROTOCOL

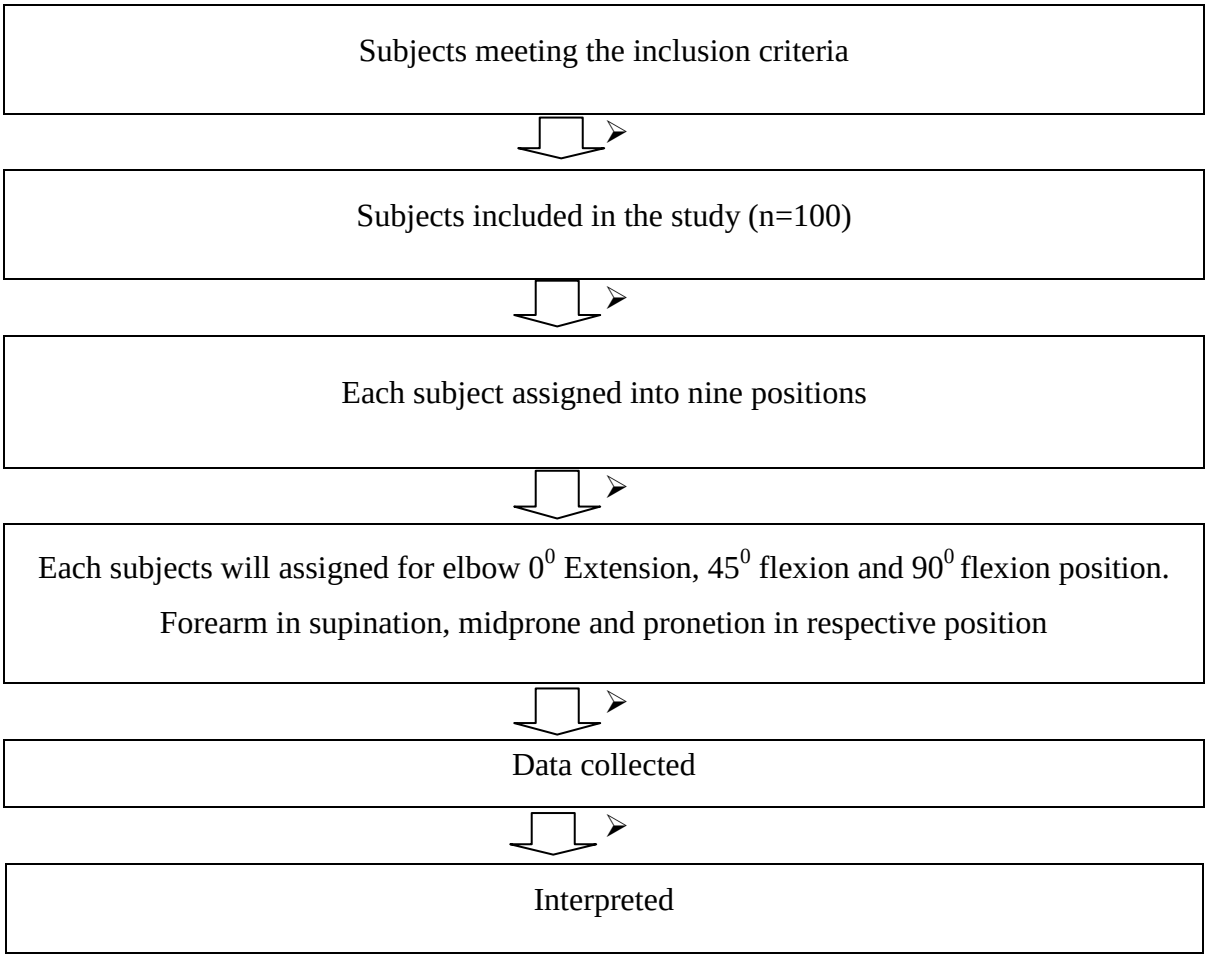

Subjects meeting the inclusion criteria
Subjects included in the study (n=100)
Each subject assigned into nine positions
Each subjects will assigned for elbow 0^0 Extension, 45^0 flexion and 90^0 flexion position.
Forearm in supination, midprone and pronetion in respective position
Data collected
Interpreted

FIGURE: 1 HAND DYNAMOMETER

3.10 STATISTICAL ANALYSIS

All the data was recorded and tabulated under following headings serial number, age, sex, and dominance, height, weight, and grip strength readings in all nine positions of elbow joint and forearm. Mean and standard deviation was calculated for age, height, weight and various grip strength readings.

Analysis of variance was calculated by using ANOVA test.

Level of significance was calculated if $p < 0.05$ it is significant

DEMOGRAPHIC PROFILE

* ***Sex of the subjects (Table no 1 & Graph no 1)***

  Out 100 untrained healthy subjects 50 were males and 50 were females.

* ***Age distribution of subjects (Table no 1 and 2 & Graph no 2)***

  Age of the subjects participated in this study was between 18 to 25 years. Average age of all 100 subjects was 20.70 years with SD= ±1.817.

  Average age of males was 20.86 years with SD= ± 2.158 and average age of females was 20.54 with SD= ± 1.368.

* ***Height of the subjects (Table no 3 & Graph no 3)***

  Average height of the subjects participated was 162.6 cms with SD =± 8.734. Average height of the male subjects was 167.99 cms with SD = ± 2.185 Average height of the female subjects was 157.3 cms with SD = ± 5.94.

* ***Weight of the subjects (Table no 3 & Graph no 4)***

  Average weight of the subjects participated was 57.19 kgs with SD =± 10.95. Average weight of the male subjects was 62.62 kgs with SD = ± 10.29. Average weight of the female subjects was 51.76 kgs with SD = ± 8.73.

* ***Dominance of the subjects (Table no 4)***

  Out of all 100 subjects 93 were right hand dominant and 7 were left hand dominant. Out of 93 right hand dominant subjects 47 subjects were males and 46 subjects were females. Out of 7 left hand dominant subjects 4 were females and 3 were males.

* ***Grip strength comparison with elbow joint in 0°, 45°& 90° with forearm in supination. (Table no 11 & Graph no 5)***

  Mean grip strength of subjects with elbow in 0° and forearm in supination was 32.27 with SD = ± 9.05 and mean grip strength of subjects with elbow 45° and forearm in supination was 29.18 with SD = ± 9.51, had t = 2.35, DF = 198, p = 0.020 which is significant.

Mean grip strength of subjects with elbow in 0° and forearm in supination was 32.27 with SD = ± 9.05 and mean grip strength of subjects with elbow 90°and forearm in supination was 30.7 with SD =± 10.1, had t = 1.18, DF = 198, p = 0.24 which is not significant.

Mean grip strength of subjects with elbow in 45° and forearm in supination was 29.18 with SD = ± 9.51 and mean grip strength of subjects with elbow 90° and forearm in supination was 30.7 with SD =± 10.1, had t = 1.07, DF = 198, p = 0.28 which is not significant.

* ***Grip strength comparison with elbow joint in 0°, 45°& 90° with forearm in midprone. (Table no 12 & Graph no 5)***

Mean grip strength of subjects with elbow in 0° and forearm in midprone was 33.36 with SD = ± 9.55 and mean grip strength of subjects with elbow 45°and forearm in midprone was 29.96 with SD =± 9.81, had t = 2.48, DF = 198, p = 0.014 which is significant.

Mean grip strength of subjects with elbow in 0° and forearm in midprone was 33.36 with SD = ± 9.55 and mean grip strength of subjects with elbow 90° and forearm in midprone was 32.44 with SD = ± 10.4, had t = 0.65, DF = 198, p = 0.52 which is not significant.

Mean grip strength of subjects with elbow in 45° and forearm in midprone was 29.96 with SD = ± 9.81 and mean grip strength of subjects with elbow 90° and forearm in midprone was 32.44 with SD = ± 10.4, had t = 1.74, DF = 198, p = 0.84 which is not significant.

* ***Grip strength comparison with elbow joint in 0°, 45°& 90° with forearm in pronation. (Table no 13 & Graph no 5)***

Mean grip strength of subjects with elbow in 0° and forearm in pronation was 30.44with SD = ± 9.42 and mean grip strength of subjects with elbow 45° and forearm in pronation was 27.11 with SD = ± 9.38, had t = 2.50, DF = 198, p = 0.013 which is significant.

Mean grip strength of subjects with elbow in 0° and forearm in pronation was 30.44 with SD = ± 9.42 and mean grip strength of subjects with elbow 90° and forearm in pronation was 27.18 with SD = ± 8.84, had t = 2.52, DF = 198, p = 0.012 which is significant.

Mean grip strength of subjects with elbow in 45° and forearm in pronation was 27.11 with SD = ± 9.38 and mean grip strength of subjects with elbow 90° and forearm in pronation was 27.18 with SD = ± 8.84, had t = 1.74, DF = 198, p = 0.96 which is not significant.

* ***Comparison of elbow joint in various position and forearm in various position (Table no 14)***

Comparison of various elbow joint positions with forearm in supination showed $F = 2.61$ and $p = 0.075$ which is not significant.

Comparison of various elbow joint positions with forearm in midprone showed $F = 3.14$ and $p = 0.045$ which is not significant.

Comparison of various elbow joint positions with forearm in pronation showed $F = 4.26$ and $p = 0.015$ which is significant.

* ***Grip strength of subjects in relation to the sex of the subjects: (Table no 5)***

Mean grip strength of 50 males and 50 females in 0° elbow and forearm in supination are 38.34 with SD = ± 7.288 and 25.600 with SD = ± 4.63 8, t = 10.92, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 45° elbow and forearm in supination are 35.9 with SD = ± 8.6 and 22.46 with SD = ± 4.07, t = 9.99, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 90° elbow and forearm in supination are 38.22 with SD = ± 8.56 and 23.12 with SD = ± 4.09, t = 11.25, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 0° elbow and forearm in midprone are 40.88with SD = ± 7.21and 25.84 with SD = ± 4.09, t = 12.82, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 45° elbow and forearm in midprone are 36.88 with SD =± 8.66 and 23.04 with SD =± 4.68, t = 9.94, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 90° elbow and forearm in midprone are 40.26 with SD = ± 8.61 and 24.62 with SD = ± 4.36, t = 11.46, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 0° elbow and forearm in pronation are 37.42 with SD = ± 7.77 and 23.46 with SD = ± 4.43, t = 11.04, DF = 98, p = 0.0000.

Mean grip strength of 50 males and 50 females in 45° elbow and forearmin pronation are 33.58 with SD =± 8.50and 20.64 with SD =± 4.51, t = 9.51, DF = 98, p = 0.0000

Mean grip strength of 50 males and 50 females in 90° elbow and forearm in pronation are 33.78 with SD = ± 7.67 and 20.78 with SD = ± 3.34, t = 10.49, DF = 98, p = 0.0000.

There was significant difference in male and female grip strength in various combinations of elbow joint and forearm position.

* ***Grip strength in relation to dominance of hand in different combinations of elbow joint and forearm position (Table no 6)***

Mean grip strength of Right hand dominant and Left hand dominant subjects in 0° elbow and forearm in supination are 32.37 with± SD = 9.20 and 31 with SD = ± 7.16, t = 0.38,p = 0.70.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 45° elbow and forearm in supination are 29.25 with SD =± 9.64 and 28.29 with SD = ± 8.12, t = 0.26,p = 0.80.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 90° elbow and forearm in supination are 30.80 with SD = ± 10.20 and 28.71 with SD = ± 9.18, t = 0.53,p = 0.60.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 0° elbow and forearm in midprone are 33.38 with± SD = 9.64 and 33.14 with SD = ± 8.86, t = 0.06,p = 0.95.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 45° elbow and forearm in midprone are 30.17 with SD =± 9.96 and 27.14 with SD = ± 7.65, t = 0.79,p = 0.43.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 90° elbow and forearm in midprone are 32.60 with SD = ± 10.60 and 30.29 with SD = ± 8.12, t = 0.57,p = 0.57.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 0° elbow and forearm in pronation are 30.45 with± SD = 9.54 and 29.14 with SD = ± 8.30, t = 0.38,p = 0.71.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 45° elbow and forearm in pronation are 27.16 with SD =± 8.30 and 26.43 with SD = ± 8.16, t = 0.20,p = 0.84.

Mean grip strength of Right hand dominant and Left hand dominant subjects in 90° elbow and forearm in pronation are 27.29 with SD = ± 8.91 and 25.71 with SD = ± 8.44, t = 0.45,p = 0.65.

There was no significant difference in grip strength of right and left hand dominant subjects in various combinations of elbow joint and forearm position. **Grip strength and height and weight co-relationship (Table no 7)**

Height and weight co-relationship with grip strength in various combinations showed positive co-relationship.

* ***Grip strength as per age distribution of subjects in different combinations elbow joint and forearm position: (Table no 8, 9, 10)***

Mean grip strength with standard deviation in different age groups in allcombinations of elbow joint and forearm position is given in table no 8, 9, and 10. Grip strength of all age distribution in 0° elbow and forearm in supinationhad $F = 5.26$, $p = 0.000$.

Grip strength of all age distribution in 45° elbow and forearm insupination had $F = 7.94$, $p = 0.000$.

Grip strength of all age distribution in 90° elbow and forearm insupination had $F = 5.47$, $p = 0.000$.

Grip strength of all age distribution in 0° elbow and forearm in midprone had $F = 5.29$, $p = 0.000$.

Grip strength of all age distribution in 45° elbow and forearm in midprone had $F = 7.70$, $p = 0.000$.

Grip strength of all age distribution in 90° elbow and forearm in midprone had $F = 7.05$, $p = 0.000$.

Grip strength of all age distribution in 0° elbow and forearm in pronation had $F = 6.39$, $p = 0.000$.

Grip strength of all age distribution in 45° elbow and forearm in pronation had $F = 6.88$, $p = 0.000$.

Grip strength of all age distribution in 90° elbow and forearm in pronation had $F = 5.84$, $p = 0.000$.

There was significant difference in grip strength in various age groups of subjects for all various combinations of elbow joint and forearm position.

TABLE NO 1

AGE AND SEX DISTRIBUTION

Age in years	Males	Females	Total
18	6	2	8
19	9	10	19
20	11	14	25
21	9	12	21
22	2	8	10
23	4	3	7
24	5	1	6
25	4	0	4
Total	50	50	100

TABLE NO 2

MEAN AGE AND STANDARD DEVIATION OF SUBJECTS

	All subjects	Males	Females
Mean Age in yrs	20.70	20.86	20.54
SD	±1.817.	± 2.158	± 1.368

TABLE NO 3

MEAN HEIGHT AND WEIGHT AND STANDARD DEVIATION OF SUBJECTS

Mean and SD	All subjects	Male	Female
Height in cms	162.6 ± 8.734.	167.99 ± 2.185	157.3 ± 5.94.
Weight in kgs	57.19 ± 10.95.	62.62 ± 10.29.	51.76 ± 8.73.

TABLE NO 4

HAND DOMINANCE OF THE SUBJECTS.

Dominance	All subjects	Males	Females.
Right	93	47	46
Left	7	3	4

TABLE NO 5

MEAN GRIP STRENGTH OF MALES AND FEMALES IN VARIOUS COMBINATIONS OF ELBOW JOINT AND FOREARM POSITION WITH SD, *t*, DF AND *p* VALUE.

	ZS **x ± sd**	**FS** **x ± sd**	**NS** **x ± sd**	**ZM** **x ± sd**	**FM** **x ± sd**	**NM** **x ± sd**	**ZP** **x ± sd**	**FP** **x ± sd**	**NP** **x ± sd**
Males	38.94 ± 7.28	35.90 ± 8.6	38.22 ± 8.56	40.88 ± 7.21	36.88 ± 8.66	40.26 ± 8.61	37.42 ± 7.77	33.58 ± 8.50	33.58 ± 7.67
Females	25.600 ± 4.63	22.46 ± 4.07	23.12 ± 4.09	25.84 ± 4.09	23.04 ± 4.68	24.62 ± 4.36	23.46 ± 4.43	20.64 ± 4.51	20.78 ± 3.94
t	10.92	9.99	11.25	12.82	9.94	11.46	11.04	9.51	10.49
DF	98	98	98	98	98	98	98	98	98
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE NO 6

MEAN GRIP STRENGTH OF RIGHT AND LEFT DOMINANT SUBJECTS WITH VARIOUS COMBINATIONS OF ELBOW JOINT AND FOREARM POSITIONS WITH SD, *t*, *p* VALUE.

	ZS **x ± sd**	**FS** **x ± sd**	**NS** **x ± sd**	**ZM** **x ± sd**	**FM** **x ± sd**	**NM** **x ± sd**	**ZP** **x ± sd**	**FP** **x ± sd**	**NP** **x ± sd**
Right	32.37 ± 9.20	29.25 ± 9.64	30.8 ± 10.2	33.38 ± 9.64	30.17 ± 9.96	32.6 ± 10.6	30.54 ± 9.54	27.16 ± 9.51	27.29 ± 8.91
Left	31 ± 7.16	28.29 ± 8.12	28.71 ± 9.18	33.14 ± 8.86	27.14 ± 7.65	30.29 ± 8.12	29.14 ± 8.30	26.43 ± 8.16	25.71 ± 8.44
t	0.38	0.26	0.53	0.06	0.79	0.57	0.38	0.20	0.45
p	0.70	0.80	0.60	0.95	0.43	0.57	0.71	0.84	0.65

TABLE NO 7

HEIGHT AND WEIGHT CORRELATION IN DIFFERENT COMBINATIONS OF ELBOW JOINT AND FOREARM POSITION.

Position	**Height r**	**Weight r**
ZS	0.640	0.644
ZM	0.672	0.690
ZP	0.630	0.683
FS	0.596	0.633
FM	0.598	0.639
FP	0.585	0.627
NS	0.562	0.615
NM	0.589	0.635
NP	0.598	0.649

TABLE NO 8

MEAN GRIP STRENGTH IN RELATION TO AGE DISTRIBUTION IN VARIOUS ELBOW JOINT AND FOREARM IN SUPINATION POSITION WITH SD, *t*, *p* VALUE.

Age in years	No. Of subjects	Elbow 0° x ± sd	Elbow 45° x ± sd	Elbow 90° x ± sd
18	8	30.5 ± 7.783	25.875 ± 7.338	29.375± 8.927
19	19	29.263 ± 6.306	25.526 ± 6.867	27.526 ± 7.968
20	25	3 1.4± 7.697	26.64± 8.05 1	27.52± 9.452
21	21	32.095 ± 7.099	29.524 ± 7.153	31.381 ± 7.896
22	10	25.4± 8.733	24.7 ± 7.273	25.3± 7.732
23	7	40.286 ± 12.816	35.857± 11.231	39 ± 13.404
24	6	40.167± 5.154	41.667± 6.002	41.5 ± 7.503
25	4	47.75 ± 9.323	48 ± 10.954	46.75 ± 7.182
F		5.26	7.94	5.47
p		0.000	0.000	0.000

TABLE NO 9

MEAN GRIP STRENGTH IN RELATION TO AGE DISTRIBUTION IN VARIOUS ELBOW JOINT AND FOREARM IN MIDPRONE POSITION WITH SD, *t*, *p* VALUE.

Age in years	No. Of subjects	Elbow 0° x ± sd	Elbow 45° x ± sd	Elbow 90° x ± sd
18	8	3 1.875 ± 8.493	26.25 ± 7.046	31.5 ± 8.799
19	19	23.842 ± 7.995	26.421 ± 7.042	27.842 ± 7.500
20	25	32.6 ± 8.02 1	27.68 ± 8.494	29.88 ± 9.5 19
21	21	32.333 ± 7.102	30.238 ± 7.918	33.143 ± 7.914
22	10	26.9 ± 9.676	24.3 ± 7.761	26.6 ± 7.604
23	7	39.143 ± 12.171	38 ± 10.847	40.143 ± 12.92
24	6	42± 5.899	42.667 ± 4.803	43.833 ± 6.210
25	4	51.5 ± 10.344	48 ± 11.888	52.5 ± 9.17
F		5.29	7.70	7.05
p		0.000	0.000	0.000

TABLE NO 10

MEAN GRIP STRENGTH IN RELATION TO AGE DISTRIBUTION IN VARIOUS ELBOW JOINT AND FOREARM IN PRONATION POSITION WITH SD, *t*, *p* VALUE.

Age in years	No. Of subjects	Elbow 0° x ± sd	Elbow 45° x ± sd	Elbow 90° x ± sd
18	8	28.5 ± 9.562	23 ± 5.127	25.75 ± 8.972
19	19	27.421 ± 7.105	23.421 ± 6.907	24.158 ± 6.50
20	25	29.16 ± 7.983	25.08 ± 8.25 1	24.64 ± 7.868
21	21	30.048 ± 6.523	26.81 ± 7.097	27.381 ± 6.823
22	10	24.1 ± 8.762	24 ± 8.433	23.4 ± 7.306
23	7	37.857 ± 13.018	34.571 ± 12.381	34.143 ± 11.23
24	6	38.5 ± 5.128	38.667 ± 5.428	35.5 ± 4.889
25	4	49.5 ± 7	44.5 ± 10.504	44 ± 9.381
F		6.39	6.88	5.84
p		0.000	0.000	0.000

TABLE NO 11

MEAN GRIP STRENGTH OF SUBJECTS WITH ELBOW 0°,45°, 90° AND FOREARM IN SUPINATION, WITH SD, *t*, DF, *p* VALVE.

Position	Mean	SD	*t*	DF	*p*
ZS	32.27	± 9.05	2.35	198	0.020
FS	29.18	± 9.51			
ZS	32.27	± 9.05	1.18	198	0.24
NS	30.7	± 10.1			
FS	39.18	± 9.51	1.07	198	0.14
NS	30.7	± 10.1			

TABLE NO 12

MEAN GRIP STRENGTH OF SUBJECTS WITH ELBOW 0°,45°, 90° AND FOREARM IN MIDPRONE, WITH SD, t, DF, p VALVE.

Position	Mean	SD	*t*	DF	*p*
ZM	33.36	± 9.55	2.48	198	0.014
FM	29.96	± 9.81			
ZM	33.39	± 9.55	0.65	198	0.52
NM	32.44	± 10.4			
FM	29.96	± 9.81	2.50	198	0.13
NM	32.44	± 10.4			

TABLE NO 13

MEAN GRIP STRENGTH OF SUBJECTS WITH ELBOW 0°,45°, 90° AND FOREARM IN PRONATION, WITH SD, *t*, DF, *p* VALVE.

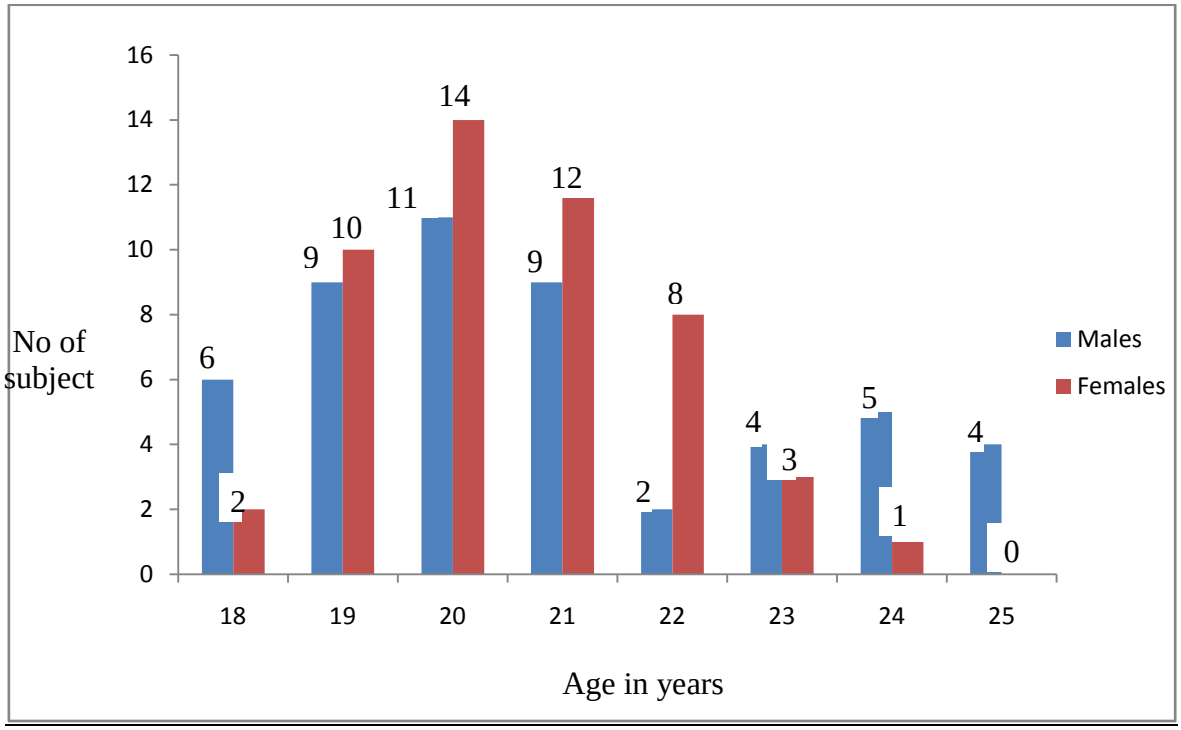
Position	Mean	SD	*t*	DF	*p*
ZP	30.44	± 9.42	2.50	198	0.013
FP	27.11	± 9.38			
ZP	30.44	± 9.42	2.52	198	0.012
NP	27.18	± 8.84			
FP	27.11	± 9.38	1.74	198	0.96
NP	27.18	± 8.84			

TABLE NO 14

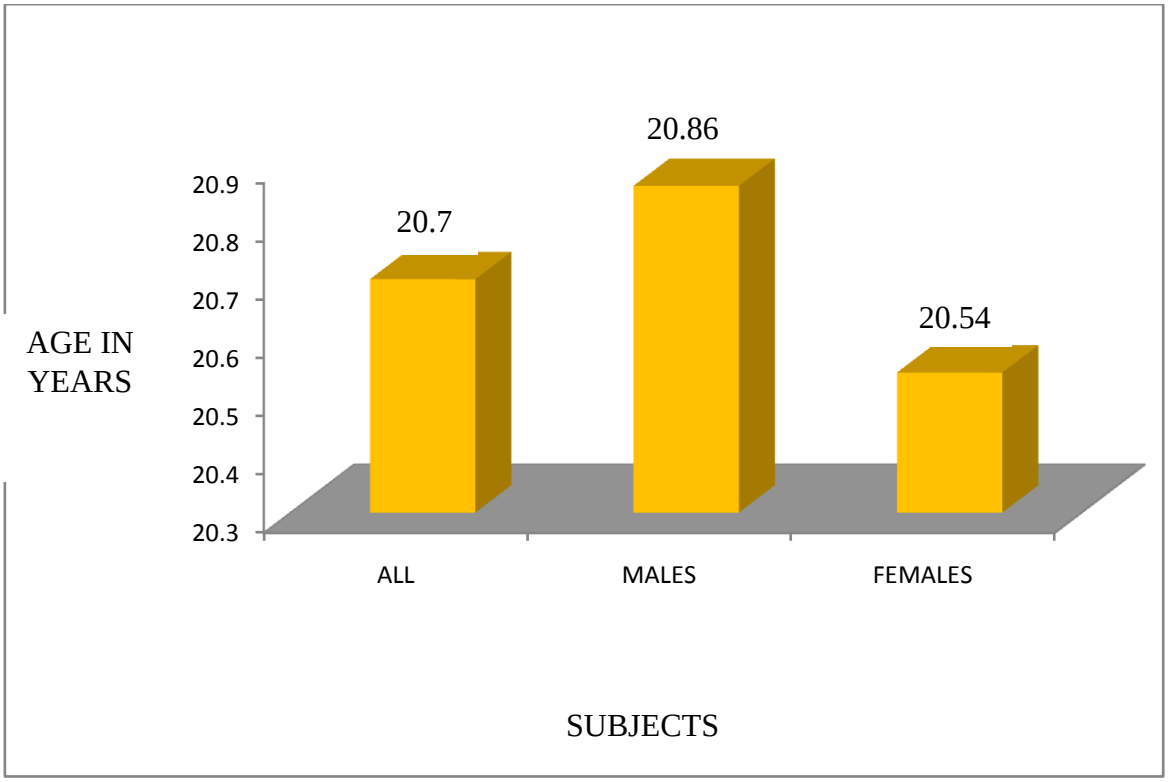
COMPARISION OF VARIOUS ELBOW JOINT POSITION WITH VARIOUS FOREARM POSTION

	***F* value**	***p* value**
ZS v/s FS FS v/s NS NS v/s ZS	2.61	0.075
ZM v/s FM FM v/s NM NM v/s ZM	3.14	0.045
ZP v/s FP FP v/s NP NP v/s ZP	4.26	0.015

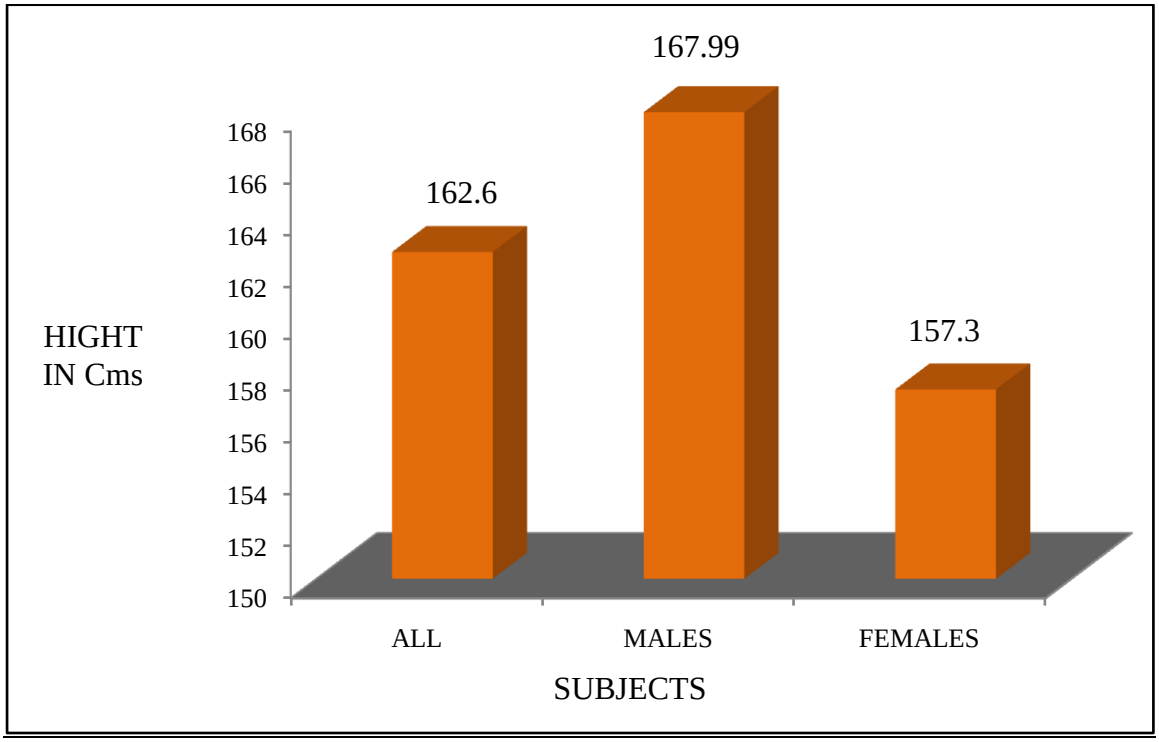
GRAPH NO 1: AGE DISTRIBUTION OF SUBJECTS



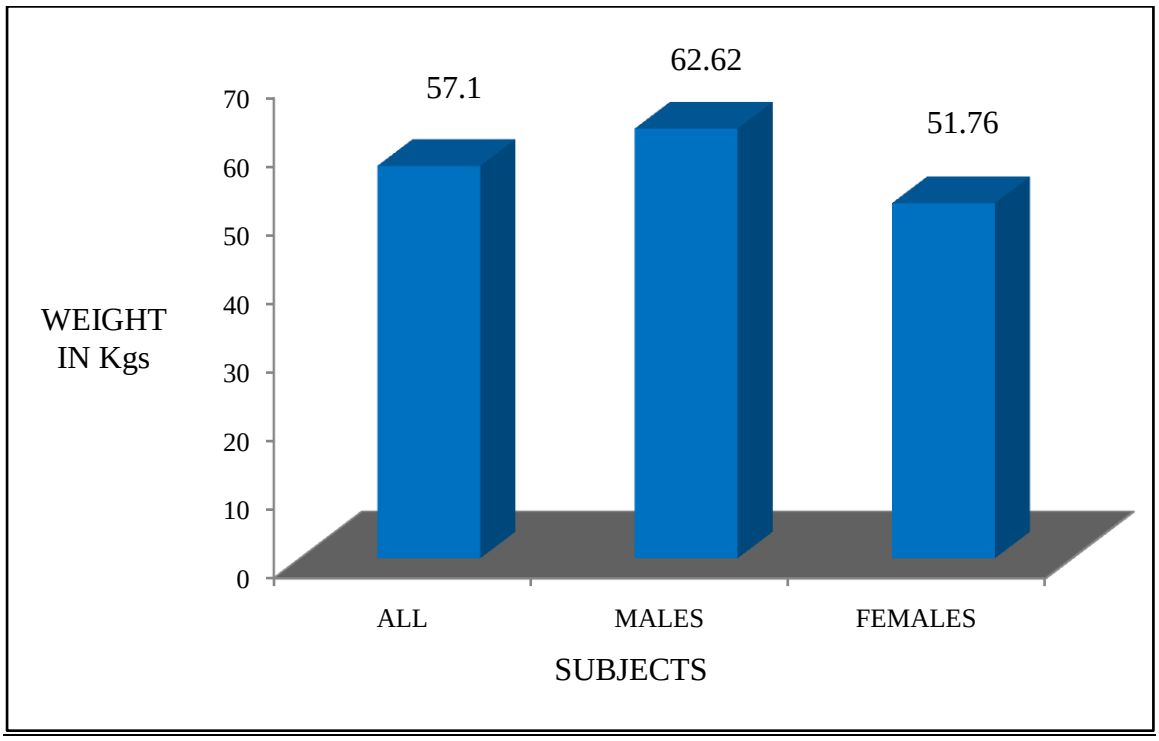
GRAPH NO 2: MEAN AGE OF THE SUBJECT



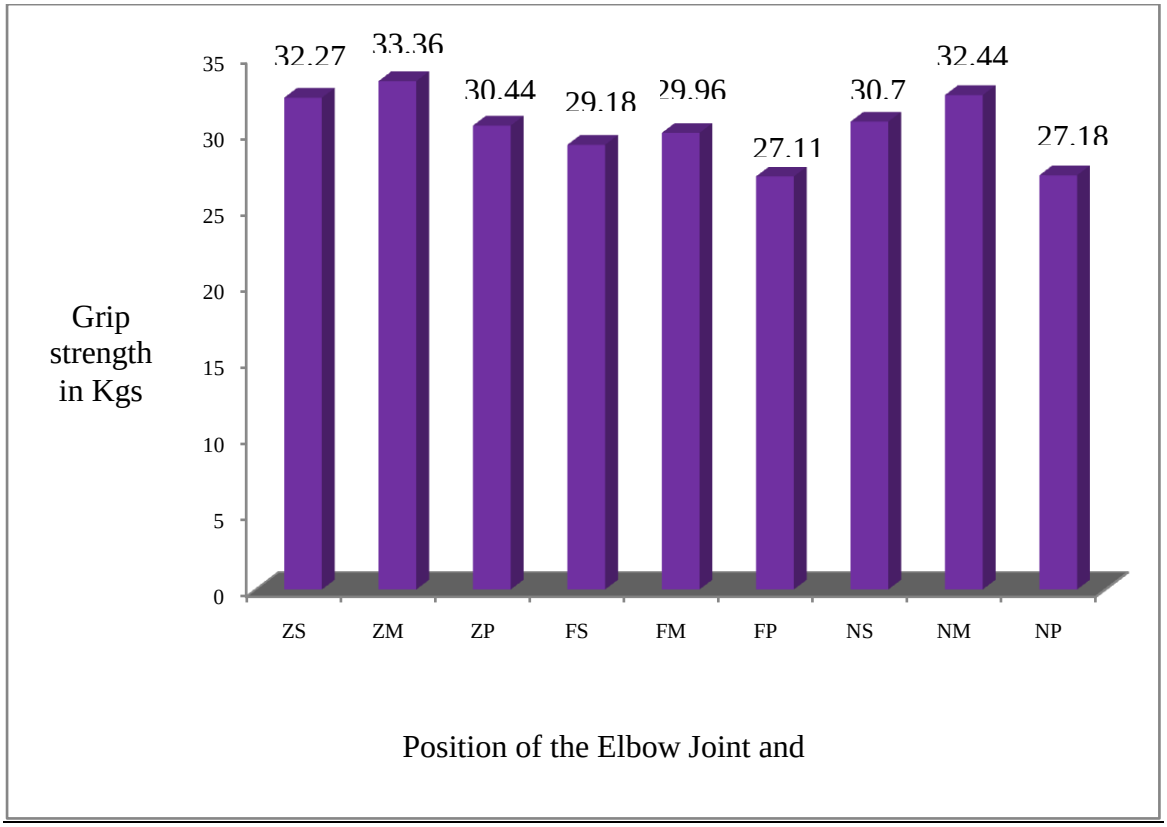
GRAPH NO 3: MEAN HEIGHT OF SUBJECTS



GRAPH NO 4: MEAN WEIGHT OF OBJECTS



GRAPH NO 5: MEAN GRIP STRENGTH IN DIFFERENT COMBINATION OF ELBOW JOINT AND FOREARM POSITION



In our study effort was made to study the effect of various combinations of elbow joint and forearm position on grip strength.

In the present study all the subjects were in age group ranging from 18-25 years. Out of all 100 subjects 50 were male and 50 were female.

Average age of the all subjects was 20.70 years with average age of males is 20.86 and average age of females is 20.54, which is shown is table no 2.

Average height of all subjects is 162.60 cms. Male's average height is 167.99 cms and female average height was 157.3 cms, which is shown in table no 3.

Average weight of all subjects is 57.76 kgs. Male's average weight 62.62 kgs and females average weight was 57.19 kgs, which is shown in table no 3.

93% of the subjects were right hand dominant and 7% of subjects were left hand dominant, which is shown in table no 4.

Main study was to compare the effect of combination of elbow joint and forearm position on grip strength in health subjects.

Studies on the effect of elbow position on grip strength have had conflicting findings. Balogunet.al (1991) and Kuzala&Vargo (1992) found greatest grip strength with elbow in full extension.[14,63]Mathiowetz (1985) found grip strength higher in 90° flexion.[16]Ferrazet.al found no relationship between

Elbow position and grip strength.[37]Richardset.al (1996) found forearm positioned in supination has greatest grip strength followed by the forearm in neutral position with pronation producing the lowest grip strength.[17]

In our study we have studied grip strength of dominant hand in various combination of elbow joint and forearm position. Data for grip strength was collected using hand dynamometer for all the subjects. Statistical analysis was done as per forearm position and elbow joint in 0°, 45°& 90°.

Mean grip strength of forearm in supination and elbow joint in 0°, 45°& 90° with standard deviation, *t* and *p* valve is given in table no 11. Elbow 0° and forearm supinated v/s elbow 45° and forearm supinated showed significant difference in grip strength. Elbow 0° and forearm-supinated v/s elbow 90° and forearm supinated showed no significant difference in grip strength. Elbow 45° and forearm-supinated v/s elbow 90° and forearm supinated showed no significant difference in grip strength.

Mean grip strength of forearm in midprone and elbow joint in 0°, 45°& 90° with standard deviation, *t* and *p* valve is given in table no 12. Elbow 0° and forearm in midprone

v/s elbow 45° and forearm in midprone showed significant difference in grip strength. Elbow 0° and forearm in midprone v/s elbow 90° and forearm in midprone showed no significant difference in grip strength. Elbow 45° and forearm in midprone v/s elbow 90° and forearm in midprone showed no significant difference in grip strength.

Mean grip strength of forearm pronated and elbow joint in 0°, 45°& 90° with standard deviation, *t* and *p* valve is given in table no 13. Elbow 0° and forearm pronated v/s elbow 45° and forearm pronated showed significant difference in grip strength. Elbow 0° and forearm-pronated v/s elbow 90° and forearm pronated showed significant difference in grip strength. Elbow 45° and forearm-pronated v/s elbow 90° and forearm pronated showed no significant difference in grip strength.

Table no 14 shows *F* and *p* value which indicates that forearm in supination and elbow joint in 0°, 45°& 90° when analyzed had no significant difference in grip strength.

Table no 14 shows *F* and p value which indicates that forearm in midprone and elbow joint in 0°, 45°& 90° when analyzed had no significant difference in grip strength.

Table no 14 shows *F* and p value which indicates that forearm in pronation and elbow joint in 0°, 45°& 90° when analyzed had significant difference in grip strength.

Reasons for various significant and non significant differences in grip strength in various combination of elbow joint and forearm position is stated below:

Starling's law states length is directly proportional to the tension developed in a muscle. Maximum tension can only be developed at on optimallength of the muscle as maximum member of cross bridges between the actin and myosin fibers occur. Muscles are able to generate moderate tension in the lengthened range, Maximal tension in the middle ranges and Minimal tension in Shortened range during a concentric/active shortening of a muscle. This muscle length tension relationship also proves as the base for active and passive insufficiency of a muscle.

One might consider length tension relationship of the muscles involved. FDS is the only primary finger flexor that crosses the elbow joint; therefore elbow position may affect the strength performance of this muscle. As a muscle is placed in a shortened position it may become incapable of generating the tension necessary to achieve a functional contraction. As the elbow is placed in more degree of flexion, placing it at a mechanical disadvantage progressively places FDS in a more shortened position, there. This may serve to explain the decrease in grip strength that resulted as degree of elbow flexion increased.

All muscles have an optimal length at which they produce maximal contraction. Any

external shortening or lengthening of a muscle changes the length tension relationship of its fibers and impairs that muscles ability to contract maximally. Supination and pronation takes place around the superior and inferior radioulnar joints. As the hand moves from supination to pronation, the direction of pull of the muscles is in the anterior or flexor compartment is changed. Potential changes in the length tension relationship one would predict a weaker grip in the pronated position than in supinated position. The change in the lengthof long flexor muscles from supination to pronation also potentially changes thesynergistic relationship among the long flexors of the fingers and the flexor and extensors muscles that stabilize the wrist joint.

The results of this study showed both significant and non-significant differences in grip strength in various combinations of elbow joint and fore arm position. Grip strength recordings in midprone and supinated forearm in various elbow in 0° and 90° were highest but there was no significant difference between them. Grip strength recordings in pronated forearm and elbow in all the positions were lowest in the study and were significant when compared between them.

Agnew & mass (1982) found that males have greater grip strength than females regardless of the testing instrument.[50]This supports our study males have greater grip strength than females. Mean grip strength of all males and females in various combination of elbow joint and forearm position is given table no 5, which males have greater grip strength than females.

In our study there were 93 right hand dominant and 7 left hand dominant subjects. When their grip strength was compared in various elbow joint and forearm position it was found that there was no significant difference in grip strength of right hand dominant and left hand dominant subjects.

Schmidt and Towes (1970) found that there is a positive correlation between grip strength, body weight and height.[52] In our study correlation between grip strength in various combination of elbow joint and forearm position, body weight and height showed positive correlation which is shown in table no 7.

Hinson and Gench (1989) found that grip strength has a curvilinear relationship to age which results in an increase in grip strength with increasing age to reach a peak at 30 –45 years and then a decrease with increasing age.[51] In our study age group of subjects was 18 – 25 years. Mean grip strength with standard deviation was calculated in various combinations of elbow joint and forearm position with all different age groups. *F* and p value is calculated for every

age group in various combination of elbow joint and forearm position, and there was significant difference in grip strength. This showed that grip strength has a curvilinear relationship to age. Data is shown in table no 8,9,10.

This demonstrates that elbow and forearm position should be an important consideration when one takes grip strength measurements. Mainly while measuring the grip strength forearm can be kept in supinated or midprone position. And elbow position would either be in 90° flexion or 0° extension these position would give relevant grip strength measurement.

The results of our study can be incorporated into treatment techniques and functional activities as per the patients needs.

5.1 LIMITATIONS OF THE STUDY

Followings are the limitations of our study: -

- The use of convenience sample limits the generalization of results of this study to the population at large.
- Only young adults of 18 to 25 years, subjects were considered for the study, thus results cannot be applied on older adults.
- The study was done on athelete and asymptomatic population only.
- Left hand dominant subjects in our study was very less compared to right hand dominant subjects.
- We used an accidental sample in college setting, thus results cannot be applied to other groups like factory workers, beauticians or farmers etc.

5.2 FUTURE STUDIES

- Study in future should be conducted in patients with hand involvement to check the implications of these results in clinical practice.
- Research should be done on older population to check and compare the results with younger population.
- Study in future can be done on equal number of right and left hand dominant subjects and find the difference.

My study concluded that

- Combination position showed different grip strength.
- The position with the highest mean grip strength was elbow 0° and forearm inmidprone.
- Followed by elbow 90° and forearm in midprone.
- Followed by elbow 0° and forearm in supination.
- Followed by elbow 90° and forearm in supination.
- Followed by elbow 0° and forearm in pronation.
- Followed by elbow 45° and forearm in midprone
- Followed by elbow 45° and forearm in supination.
- Followed by elbow 90° and forearm in pronation.
- Followed by elbow 45° and forearm in pronation.
- Elbow joint and forearm position should be considered during grip strength measurement.
- As per the patients needs position of elbow joint and forearm should be considered during the treatment techniques and functional activities.

Study was to find the effect of combination of elbow joint and forearm position on grip strength in healthy individuals. 100 healthy subjects were selected and grip strength was measured using hand dynamometer in various combinations of elbow joint and forearm positions. Statiscal analysis was done to find difference in grip strength in various combinations of elbow joint and forearm positions. Few combinations of elbow joint and forearm were significant. They are given below:

- Elbow 0° and forearm supinated versus elbow 45° and forearm supinated showed significant difference in grip strength.
- Elbow 0° and forearm in midprone versus elbow 45° and forearm in midprone showed significant difference in grip strength.
- Elbow 0° and forearm pronated versus elbow 45° and forearm pronated showed significant difference in grip strength.
- Elbow 0° and forearm-pronated versus elbow 90° and forearm pronated showed significant difference in grip strength.
- Few combinations, which are not significant, are given below:
- Elbow 0° and forearm-supinated versus elbow 90° and forearm supinated showed no significant difference in grip strength.
- Elbow 45° and forearm-supinated versus elbow 90° and forearm supinated showed no significant difference in grip strength.
- Elbow 0° and forearm in midprone versus elbow 90° and forearm in midprone showed no significant difference in grip strength.
- Elbow 45° and forearm in midprone versus elbow 90° and forearm in midprone showed no significant difference in grip strength.
- Elbow 45° and forearm-pronated versus elbow 90° and forearm pronated showed no significant difference in grip strength.
- Over all analysis as per forearm position and various elbow joint positions showed following result:
- Forearm in supination and elbow joint in 0°, 45°& 90° when analyzed had no significant difference in grip strength.
- Forearm in midprone and elbow joint in 0°, 45°& 90° when analyzed had no significant difference in grip strength.
- Forearm in pronation and elbow joint in 0°, 45°& 90° when analyzed had significant difference in grip strength.

This result can influence the importance of elbow joint and forearm position in overall assessment of fitness in healthy individuals and can be a guideline in rehabilitation of the patients.

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ANNEXURE NO 1

DATA COLLECTION SHEET

Name : _____

Age : _____ No: _____

Sex : _____

Occupation : _____

Height in cms : _____

Weight in kgs : _____

Dominance : Right: _____ Left: _____

Measurements :

	1st Attempt	2nd Attempt	3rd Attempt	Best Attempt
Elbow 0°& Forearm Supinated				
Elbow 0°& Forearm Midprone				
Elbow 0°& Forearm Pronated				
Elbow 45°& Forearm Supinated				
Elbow 45°& Forearm Midprone				
Elbow 45°& Forearm Pronated				
Elbow 90°& Forearm Supinated				
Elbow 90°& Forearm Midprone				
Elbow 90°& forearm pronated				

Date: Evaluator

ANNEXURE NO 2

CONSENT FORM

I _____Voluntarily declare to participate in the research study entitled **"EFFECT OF A COMBINED ELBOW AND FOREARM POSITION ON GRIP STRENGTH IN ATHELETESSUBJECTS**".The researchers have explained me about the study, risk of participation and they have answered my all questions and queries regarding the study to my satisfaction.

Signature of the subject: .

Signature of the Investigator: .

Subject is fit or unfit to participate in the study:

Date:

ANNEXURE NO 3

MASTER CHART

Grip strength in kgs														
						Group I Elbow 0û			Group II Elbow 45û			Group III Elbow 90û		
S no.	Age (yrs)	Sex	Dominance	Height (cms)	Weight (kgs)	SPN (ZS)	MID (ZM)	PRN (ZP)	SPN (FS)	MID (FM)	PRN (FP)	SPN (NS)	MID (NM)	PRN (NP)
1	24	M	R	176.3	64	38	44	38	46	48	42	45	48	32
2	25	M	R	177.8	85	41	47	46	46	46	44	44	48	48
3	21	M	R	182.5	70	35	36	34	35	35	28	34	38	28
4	22	F	R	163	52	26	27	26	30	26	38	25	28	25
5	24	M	R	165.2	64	44	47	43	43	44	41	46	48	37
6	23	F	R	142.8	41	25	26	25	24	25	24	24	27	24
7	22	F	R	157	55	22	25	20	20	20	20	23	26	21
8	25	M	R	170.3	78	50	55	52	60	56	50	51	58	48
9	23	M	R	178.6	72	48	47	46	45	47	46	48	49	45
10	21	F	R	155	51	20	24	23	22	23	22	21	26	21

11	22	F	R	151.4	56	24	22	20	23	21	18	25	20	20
12	21	M	R	155	56	36	38	36	38	40	38	40	42	36
13	23	M	R	175	80	60	56	56	54	54	56	59	58	50
14	20	M	R	178	53	44	44	40	38	42	40	44	45	38
15	20	F	R	156.6	51	26	26	24	24	22	22	22	28	20
16	22	F	R	155	54	25	24	24	20	24	22	20	26	22
17	21	M	L	171.8	66	40	42	38	42	42	41	44	44	42
18	20	M	L	175.4	66	32	38	28	30	30	30	20	28	22
19	21	F	R	159.6	48	26	28	26	26	24	18	26	24	22
20	25	M	R	180.5	73	60	64	58	52	58	54	54	62	50
21	24	M	R	168.4	62	46	47	46	50	48	46	47	47	42
22	21	F	R	158	49	32	29	26	30	30	26	30	30	27
23	20	F	R	160	59	32	34	32	32	34	30	35	36	30
24	21	F	R	161.3	57	28	27	26	25	26	24	26	28	24
25	24	M	R	169.3	58	38	38	36	40	37	33	34	38	30
26	21	F	R	156	50	28	22	28	28	28	26	30	30	24

27	22	F	R	150	35	16	18	17	18	16	18	16	20	16
28	25	M	R	165	76	40	40	42	34	32	30	38	42	30
29	21	F	L	157.5	80	26	30	26	22	22	20	28	28	22
30	23	M	R	170	74	48	48	48	38	44	36	48	50	40
31	22	F	R	154.7	41	20	20	18	20	20	18	22	24	19
32	22	F	R	155	47	20	22	17	20	19	18	24	20	20
33	21	M	R	177.6	70	36	34	34	30	32	30	32	36	32
34	23	F	R	153.4	54	34	30	28	26	30	25	28	30	24
35	23	M	R	167.3	58	41	42	40	38	38	31	40	42	34
36	21	M	R	172.6	80	40	42	38	38	40	36	42	44	38
37	23	F	R	165	65	26	25	22	26	28	24	26	25	22
38	24	F	R	158	60	32	32	32	33	38	32	30	34	32
39	19	M	R	158	58	38	38	36	38	36	36	40	38	36
40	20	M	R	160	53	30	30	28	29	29	29	31	32	28
41	22	F	R	153	48	20	22	20	22	21	18	20	22	18
42	21	M	R	160.6	59	42	42	36	33	40	30	39	40	30

43	22	M	R	170	72	36	42	36	36	36	34	38	40	36
44	21	F	R	163	63	34	30	32	34	34	30	28	34	28
45	21	F	L	155	41	30	28	26	24	24	22	28	30	24
46	19	M	R	160	50	34	34	28	30	32	24	30	34	28
47	21	M	R	167.6	48	30	30	28	28	24	28	28	32	23
48	21	M	R	160.3	50	47	48	45	45	46	38	50	50	38
49	20	F	R	158	42	26	22	20	20	20	18	20	21	20
50	20	M	R	158	81	44	50	44	46	46	44	48	52	42
51	20	F	R	150	42	18	22	20	18	20	16	18	22	16
52	19	M	R	172	55	34	35	32	30	34	32	30	40	30
53	19	M	R	173	54	34	44	38	38	36	32	40	30	30
54	20	M	R	165	57	32	40	32	32	40	32	36	40	28
55	18	M	R	161	63	34	38	36	30	30	30	36	40	28
56	19	M	R	158	53	36	38	34	28	24	28	28	30	28

57	19	M	R	158	53	36	42	32	36	38	36	34	36	32
58	18	M	R	168	52	36	38	32	24	30	24	34	36	32
59	19	F	R	150	44	22	22	22	22	22	20	24	24	22
60	20	F	R	168	60	37	38	30	22	28	22	22	28	30
61	20	F	R	150	65	26	22	24	20	22	20	20	20	18
62	18	F	R	152.6	39	24	24	18	24	20	18	22	22	18
63	19	F	R	160	47	25	26	20	20	24	20	25	26	20
64	18	F	R	152	47	20	20	15	18	18	16	16	20	16
65	19	F	R	152	45	24	22	22	19	20	18	22	20	20
66	19	F	R	164	52	27	25	20	20	20	16	20	20	18
67	19	F	R	155	47	23	23	23	20	18	18	16	18	14
68	19	F	R	161	53	22	26	18	18	20	17	20	20	18
69	20	M	R	160.6	55	43	37	36	38	41	38	48	47	40
70	24	M	R	170	65	43	44	36	38	41	38	47	48	40
71	20	M	L	180	78	41	46	43	36	30	32	38	38	32
72	18	M	R	148.4	49	30	32	28	22	24	20	28	30	22

73	19	M	R	168	52	36	38	34	24	24	16	36	36	34
74	17	M	R	168	70	45	46	45	42	40	30	45	46	44
75	22	M	R	163.4	58	45	47	43	38	40	36	40	40	37
76	19	M	R	164	50	30	33	27	24	30	22	30	27	23
77	19	M	R	162	70	40	44	42	34	38	32	43	40	30
78	20	M	R	178	70	38	42	32	34	34	32	30	30	30
79	20	F	R	161	64	32	35	31	17	18	17	20	22	16
80	21	F	R	159	58	31	30	28	24	28	20	29	30	20
81	19	F	L	155	50	25	24	23	24	22	20	23	22	20
82	19	F	L	165	63	23	24	20	20	20	20	20	22	18
83	21	F	R	173	55	27	30	23	22	23	18	26	26	22
84	20	F	R	165	63	30	28	26	22	26	18	28	28	24
85	21	M	R	165	62	40	39	36	32	34	30	36	40	34
86	19	F	R	161	52	24	26	28	22	24	20	22	26	20
87	20	M	R	175	56	42	35	44	34	32	30	34	40	28
88	20	M	R	173	69	24	30	20	20	20	20	20	20	20

89	20	F	R	161	48	36	32	32	22	24	20	22	28	18
90	20	M	R	175	68	35	36	35	32	34	28	30	36	28
91	19	F	R	161	55	23	22	22	18	20	18	20	20	18
92	20	F	R	148	43	23	24	20	18	18	16	20	22	16
93	21	F	R	165	48	24	26	22	22	20	20	22	22	20
94	20	F	R	150	49	22	27	18	18	18	16	20	20	16
95	20	F	R	165	52	26	27	22	22	22	20	22	22	18
96	20	F	R	148	35	23	22	20	18	16	15	18	18	16
97	20	F	R	158	63	23	28	28	24	26	22	22	24	22
98	21	F	R	153	50	22	24	20	20	20	18	20	22	20
99	18	M	R	158	49	27	27	26	22	22	22	26	30	22
100	18	M	R	165	47	28	30	28	25	26	24	28	28	24

ANNEXURE NO 1

DATA COLLECTION SHEET

Name : _____

Age : _____ No: _____

Sex : _____

Occupation : _____

Height in cms : _____

Weight in kgs : _____

Dominance : Right: _____ Left: _____

Measurements :

	1st Attempt	2nd Attempt	3rd Attempt	Best Attempt
Elbow 0°& Forearm Supinated				
Elbow 0°& Forearm Midprone				
Elbow 0°& Forearm Pronated				
Elbow 45°& Forearm Supinated				
Elbow 45°& Forearm Midprone				
Elbow 45°& Forearm Pronated				
Elbow 90°& Forearm Supinated				
Elbow 90°& Forearm Midprone				
Elbow 90°& forearm pronated				

Date: Evaluator

ANNEXURE NO 2

CONSENT FORM

I _____Voluntarily declare to participate in the research study entitled **"EFFECT OF A COMBINED ELBOW AND FOREARM POSITION ON GRIP STRENGTH IN ATHELETESSUBJECTS**".The researchers have explained me about the study, risk of participation and they have answered my all questions and queries regarding the study to my satisfaction.

Signature of the subject: .

Signature of the Investigator: .

Subject is fit or unfit to participate in the study:

Date:

ANNEXURE NO 3

MASTER CHART

Grip strength in kgs														
						Group I Elbow 0û			Group II Elbow 45û			Group III Elbow 90û		
S no.	Age (yrs)	Sex	Dominance	Height (cms)	Weight (kgs)	SPN (ZS)	MID (ZM)	PRN (ZP)	SPN (FS)	MID (FM)	PRN (FP)	SPN (NS)	MID (NM)	PRN (NP)
1	24	M	R	176.3	64	38	44	38	46	48	42	45	48	32
2	25	M	R	177.8	85	41	47	46	46	46	44	44	48	48
3	21	M	R	182.5	70	35	36	34	35	35	28	34	38	28
4	22	F	R	163	52	26	27	26	30	26	38	25	28	25
5	24	M	R	165.2	64	44	47	43	43	44	41	46	48	37
6	23	F	R	142.8	41	25	26	25	24	25	24	24	27	24
7	22	F	R	157	55	22	25	20	20	20	20	23	26	21
8	25	M	R	170.3	78	50	55	52	60	56	50	51	58	48
9	23	M	R	178.6	72	48	47	46	45	47	46	48	49	45
10	21	F	R	155	51	20	24	23	22	23	22	21	26	21
11	22	F	R	151.4	56	24	22	20	23	21	18	25	20	20

12	21	M	R	155	56	36	38	36	38	40	38	40	42	36
13	23	M	R	175	80	60	56	56	54	54	56	59	58	50
14	20	M	R	178	53	44	44	40	38	42	40	44	45	38
15	20	F	R	156.6	51	26	26	24	24	22	22	22	28	20
16	22	F	R	155	54	25	24	24	20	24	22	20	26	22
17	21	M	L	171.8	66	40	42	38	42	42	41	44	44	42
18	20	M	L	175.4	66	32	38	28	30	30	30	20	28	22
19	21	F	R	159.6	48	26	28	26	26	24	18	26	24	22
20	25	M	R	180.5	73	60	64	58	52	58	54	54	62	50
21	24	M	R	168.4	62	46	47	46	50	48	46	47	47	42
22	21	F	R	158	49	32	29	26	30	30	26	30	30	27
23	20	F	R	160	59	32	34	32	32	34	30	35	36	30
24	21	F	R	161.3	57	28	27	26	25	26	24	26	28	24
25	24	M	R	169.3	58	38	38	36	40	37	33	34	38	30
26	21	F	R	156	50	28	22	28	28	28	26	30	30	24
27	22	F	R	150	35	16	18	17	18	16	18	16	20	16

28	25	M	R	165	76	40	40	42	34	32	30	38	42	30
29	21	F	L	157.5	80	26	30	26	22	22	20	28	28	22
30	23	M	R	170	74	48	48	48	38	44	36	48	50	40
31	22	F	R	154.7	41	20	20	18	20	20	18	22	24	19
32	22	F	R	155	47	20	22	17	20	19	18	24	20	20
33	21	M	R	177.6	70	36	34	34	30	32	30	32	36	32
34	23	F	R	153.4	54	34	30	28	26	30	25	28	30	24
35	23	M	R	167.3	58	41	42	40	38	38	31	40	42	34
36	21	M	R	172.6	80	40	42	38	38	40	36	42	44	38
37	23	F	R	165	65	26	25	22	26	28	24	26	25	22
38	24	F	R	158	60	32	32	32	33	38	32	30	34	32
39	19	M	R	158	58	38	38	36	38	36	36	40	38	36
40	20	M	R	160	53	30	30	28	29	29	29	31	32	28
41	22	F	R	153	48	20	22	20	22	21	18	20	22	18
42	21	M	R	160.6	59	42	42	36	33	40	30	39	40	30

43	22	M	R	170	72	36	42	36	36	36	34	38	40	36
44	21	F	R	163	63	34	30	32	34	34	30	28	34	28
45	21	F	L	155	41	30	28	26	24	24	22	28	30	24
46	19	M	R	160	50	34	34	28	30	32	24	30	34	28
47	21	M	R	167.6	48	30	30	28	28	24	28	28	32	23
48	21	M	R	160.3	50	47	48	45	45	46	38	50	50	38
49	20	F	R	158	42	26	22	20	20	20	18	20	21	20
50	20	M	R	158	81	44	50	44	46	46	44	48	52	42
51	20	F	R	150	42	18	22	20	18	20	16	18	22	16
52	19	M	R	172	55	34	35	32	30	34	32	30	40	30
53	19	M	R	173	54	34	44	38	38	36	32	40	30	30
54	20	M	R	165	57	32	40	32	32	40	32	36	40	28
55	18	M	R	161	63	34	38	36	30	30	30	36	40	28
56	19	M	R	158	53	36	38	34	28	24	28	28	30	28

57	19	M	R	158	53	36	42	32	36	38	36	34	36	32
58	18	M	R	168	52	36	38	32	24	30	24	34	36	32
59	19	F	R	150	44	22	22	22	22	22	20	24	24	22
60	20	F	R	168	60	37	38	30	22	28	22	22	28	30
61	20	F	R	150	65	26	22	24	20	22	20	20	20	18
62	18	F	R	152.6	39	24	24	18	24	20	18	22	22	18
63	19	F	R	160	47	25	26	20	20	24	20	25	26	20
64	18	F	R	152	47	20	20	15	18	18	16	16	20	16
65	19	F	R	152	45	24	22	22	19	20	18	22	20	20
66	19	F	R	164	52	27	25	20	20	20	16	20	20	18
67	19	F	R	155	47	23	23	23	20	18	18	16	18	14
68	19	F	R	161	53	22	26	18	18	20	17	20	20	18
69	20	M	R	160.6	55	43	37	36	38	41	38	48	47	40
70	24	M	R	170	65	43	44	36	38	41	38	47	48	40
71	20	M	L	180	78	41	46	43	36	30	32	38	38	32
72	18	M	R	148.4	49	30	32	28	22	24	20	28	30	22

73	19	M	R	168	52	36	38	34	24	24	16	36	36	34
74	17	M	R	168	70	45	46	45	42	40	30	45	46	44
75	22	M	R	163.4	58	45	47	43	38	40	36	40	40	37
76	19	M	R	164	50	30	33	27	24	30	22	30	27	23
77	19	M	R	162	70	40	44	42	34	38	32	43	40	30
78	20	M	R	178	70	38	42	32	34	34	32	30	30	30
79	20	F	R	161	64	32	35	31	17	18	17	20	22	16
80	21	F	R	159	58	31	30	28	24	28	20	29	30	20
81	19	F	L	155	50	25	24	23	24	22	20	23	22	20
82	19	F	L	165	63	23	24	20	20	20	20	20	22	18
83	21	F	R	173	55	27	30	23	22	23	18	26	26	22
84	20	F	R	165	63	30	28	26	22	26	18	28	28	24
85	21	M	R	165	62	40	39	36	32	34	30	36	40	34
86	19	F	R	161	52	24	26	28	22	24	20	22	26	20
87	20	M	R	175	56	42	35	44	34	32	30	34	40	28
88	20	M	R	173	69	24	30	20	20	20	20	20	20	20

89	20	F	R	161	48	36	32	32	22	24	20	22	28	18
90	20	M	R	175	68	35	36	35	32	34	28	30	36	28
91	19	F	R	161	55	23	22	22	18	20	18	20	20	18
92	20	F	R	148	43	23	24	20	18	18	16	20	22	16
93	21	F	R	165	48	24	26	22	22	20	20	22	22	20
94	20	F	R	150	49	22	27	18	18	18	16	20	20	16
95	20	F	R	165	52	26	27	22	22	22	20	22	22	18
96	20	F	R	148	35	23	22	20	18	16	15	18	18	16
97	20	F	R	158	63	23	28	28	24	26	22	22	24	22
98	21	F	R	153	50	22	24	20	20	20	18	20	22	20
99	18	M	R	158	49	27	27	26	22	22	22	26	30	22
100	18	M	R	165	47	28	30	28	25	26	24	28	28	24